Optimal inventory management in case of fluctuating market conditions

M. Deceuninck
Ghent University, Department of Industrial Systems Engineering and Product Design
e-mail : matthias.deceuninck@ugent.be

D. Fiems
Ghent University, Department of Telecommunication and Information Processing
e-mail : df@telin.be

S. De Vuyst
Ghent University, Department of Industrial Systems Engineering and Product Design
e-mail : stijn.devuyst@ugent.be

Résumé

A cost-effective inventory management is crucial in the highly competitive environment in which companies operate today. Traditionally, the purchase and inventory cost as well as the demand are assumed to be constant along the replenishment cycle. In this work, we relaxed these assumptions and the costs are subject to certain market tendencies. Assuming Markovian demand and price fluctuations, the optimal ordering strategy is determined by a Markov decision process (MDP) approach.

Usually, the analysis of inventory systems is carried out without considering the impact of price fluctuations. Most studies that attempt to capture price evolutions such as inflation, are formulated in a static environment where demand is assumed to be constant over time. This study most closely relates to De Cuypere et al. [1], in which a discrete-time Markovian model with stochastic demand and market price fluctuations is proposed. In contrast to [1] which considers a price model that fluctuates around a long-term average, our model assumes two distinct market conditions : the price or cost can either be subject to a downward trend or an upward trend. This way, we can incorporate factors such as political and regulatory changes, new technology or changing market conditions. When the price level follows the upward trend, the probability of a price increase α is higher than the probability of a price decrease β. In other words, the price is expected to increase. The opposite is true in case of a downward trend (γ is smaller than λ, respectively denoting the probability of a price increase and price decrease for a downward trend). The probability of a transition between the two trends depends on the price level as well as on the market conditions. A transition from an upward trend to a downward trend is denoted by δ, while the opposite transition is denoted by ϵ. For each state, there are six possible states to which the market can move to. In an upward trend, the price at the next time step may rise, fall or stay the same and is possibly accompanied with a transition to the other market trend. The dependence on the price level is accomplished by the introduction of an extra parameter v, which denotes the rate at which ϵ or δ decrease.

Besides price fluctuations, demand fluctuations are also considered to influence the inventory system of a product. The inter-arrival time between successive demands is modelled by a negative binomially distribution with parameters p and r, which respectively denote the success probability and the number of stages. This allows us to investigate the impact of different variabilities and its use is justified by empirical evidence [2]. The maximum order quantity is equal to the inventory capacity C. With a low capacity, there can be less anticipated on a future price increase. Thus the modelling of the stochastic demand essentially comes down to a Markov chain of Cr states.

By combining the two sub-models, we obtain a three-dimensional discrete-time Markov chain. $S_{j,k,l}$ represents for instance the state with an inventory of $C-j$ products, price level k and demand stage l. To determine an optimal ordering policy, we take immediate and future costs into account. The total cost function includes the inventory cost, purchase cost and fixed order cost. By introducing a fictional inventory level of -1 in the model, we can easily extend the model and take the cost of lost sales into account as well. The aim of this study is to investigate the influence of the market conditions, inflation rate, variability, etc. on the optimal order policy. The optimal order policies for each states will be compared with traditional policies such as the EOQ model adjusted for inflation. Preliminary results already indicate that that a relative small change in market market parameters, can lead to quite different optimal policies. This stresses the importance of customizing the order policy to the market tendency of each material separately.

Références

[1] E. De Cuypere, K. De Turck, H. Bruneel, and D. Fiems. Optimal inventory management in a fluctuating market. *Analytical and Stochastic Modeling Techniques and Applications*, 158–170, 2013.

[2] R. Deemer, A.J. Kaplan, and W.K Kruse. Application of Negative Binomial Probability to Inventory Control, 1974.